

Regulation of CVS (2)

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ILOs

By the end of this lecture the student should be able to:

1. Describe the chemoreceptor reflex and explain its significance.
2. Describe Cushing reflex.
3. List the factors that affect the heart rate and explain their effects.
4. Apply the information studied in this section to solve a clinical problem or explain clinical case.

3. Peripheral chemoreceptor reflex

- Peripheral arterial chemoreceptors are located in the carotid and aortic bodies which have very high rates of blood flow.
- They are stimulated by chemical changes in blood: decreases in partial pressure of oxygen (PO_2), and, also, increase PCO_2 and increase in hydrogen ion concentration (low pH).
- Chemoreceptors exert their main effects on respiration; however, their activation, also, leads to vasoconstriction.
- Heart rate changes are variable and depend on various factors, including changes in respiration.
- A direct effect of chemoreceptor activation is to increase vagal nerve activity (increase in parasympathetic outflow) to the heart that produces a transient decrease in heart rate.
- The slowing of the heart rate is only transient, because these peripheral are primarily involved in control of breathing and hypoxia, and causes hyperpnea (increase in ventilation) and increased catecholamine secretion from the adrenal medulla, both of which produce tachycardia and an increase in cardiac output. These compensate for the bradycardia induced by peripheral chemoreceptor stimulation.
- These chemoreceptors are stimulated when the blood pressure falls below 80 mm Hg (e.g. hemorrhage that produces hypotension) due to decreased blood flow to the chemoreceptors and consequent stagnant hypoxia of these receptors.

II. Control by higher centers

1. The cerebral cortex, limbic system and hypothalamus

- Descending tracts from the cerebral cortex (particularly the limbic cortex) to the hypothalamus lead to stimulation of vasomotor area that causes increase blood pressure and tachycardia.
- This occurs in emotions such as stress and anger.

2. Respiratory centers

- The heart rate increases during inspiration and decreases during expiration. This is called respiratory sinus arrhythmia.
- The tachycardia during inspiration is because during inspiration:
 - Irradiation of impulses from respiratory center in medulla inhibits cardioinhibitory center causing decreased activity in vagal nerve and ↓vagal tone that leads to increase the heart rate.
 - Lung inflation causes vagal inhibition (During inspiration, impulses in the vagi from the stretch receptors in the lungs inhibit the cardio-inhibitory area in the medulla oblongata).
 - Increased venous return causes stimulation of the atrial stretch receptors which leads to increased heart rate.

3. Central chemoreceptors (Cushing reflex)

- When intracranial pressure is increased (e.g., tumors, head injury), there is compression of cerebral arteries, which results in decreased blood supply to RVLM neurons, and local hypoxia and hypercapnia occurs.
- This activates central chemoreceptors located in the medulla resulting in increase in sympathetic outflow to the blood vessels that causes V.C. which leads to an increase in arterial blood pressure.
- This rise in systemic arterial blood pressure (Cushing reflex) tends to restore the blood flow to the medulla.
- The rise in blood pressure causes a reflex decrease in heart rate via the arterial baroreceptors. This is why bradycardia rather than tachycardia is characteristically seen in patients with increased intracranial pressure.

III. Control by reflexes initiated outside the CVS

1. Reflex response to pain

- Pain (mild and moderate) usually causes a rise in blood pressure and tachycardia via afferent impulses in the reticular formation converging in the RVLM.

- However, prolonged severe pain and deep pain may cause V.D., bradycardia, and fainting.

2. Reflexes from receptors in exercising skeletal muscle

- Muscular exercise
 - stimulation of proprioceptors
 - stimulation of afferent fibers from the skeletal muscle
 - stimulation of RVLM
 - Reflex tachycardia and increased arterial blood pressure

Factors Affecting Heart Rate

Heart rate accelerated by:	Heart rate slowed by:
Decreased activity of arterial baroreceptors	Increased activity of arterial baroreceptors
Increased activity of atrial stretch receptors	Expiration
Inspiration	Fear
Excitement	Grief
Anger	Stimulation of pain fibers in trigeminal nerve
Most painful stimuli	Increased intracranial pressure
Hypoxia (Moderate)	Severe hypoxia & acidosis
Exercise	Hyperkalemia
Thyroid hormones	Acetylcholine
Fever	
Epinephrine	

Increase of body temperature by 1°C, results in increase of heart rate by 10 bpm

N.B.

- Stimuli that increase heart rate, also, increase arterial blood pressure and vice versa except in 2 cases:
 - Stimulation of atrial stretch receptors → ↓ ABP & ↑ HR
 - Cushing reflex: ↑ intracranial tension → ↑ ABP & ↓ HR